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THE PRINCIPAL INSECT ENEMIES OF GROWING WHEAT.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY,
Washington, D. C., April 6, 1901.

SIR: I have the honor to transmit herewith for publication an account of the more important insect enemies of growing wheat, prepared by Mr. C. L. Marlatt, first assistant entomologist. This paper is the address, slightly revised, delivered before the Winter Wheat Millers' League, in Chicago, June 13, 1900, and was prepared under my direction in response to an earnest request from the secretary of the League, Mr. E. E. Perry. As showing the importance of the subject it may be stated that the publication of this paper and its general distribution among the winter wheat growers of the Mississippi Valley was desired by the League, with the view of limiting the losses from insect pests, and notably the Hessian fly, the ravages of which last-named insect in 1899–1900 so reduced the normal yield of wheat as to seriously interfere with the winter wheat milling interests. The paper is a condensed account of the principal insect depredators on growing wheat, discussed chiefly from the standpoint of means of control, and as covering an important subject and being a valuable aid to the correspondence of this Division its publication as a Farmers' Bulletin is recommended.

Respectfully,

L. O. HOWARD,
Entomologist.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE PRINCIPAL INSECT ENEMIES OF GROWING WHEAT.

INTRODUCTION.

There are numerous insects, the number running into the hundreds, which feed on and injure growing wheat. Most of these insects are of rare or chance occurrence, and have no economic importance whatever, although the fact that they are found on wheat often leads the farmer to be curious about them or unnecessarily arouses his fears. The great proportion of the losses to wheat fields which is chargeable to insects is due to the attacks of less than a half a dozen species. These, in the order of their importance, are the chinch bug, the Hessian fly, the wheat midge, and the grain plant louse. Of second-rate importance are such insects as the wheat strawworms, the wheat bulb worm, army worms, cutworms, and various sawflies. Then there follows a great horde of insects of minor importance which need not be considered in this connection. This is leaving out of consideration the locusts, or grasshoppers, including the Rocky Mountain, or migratory species, which occasionally injure wheat, but such injury is unusual and as a rule limited to migrations of locusts from one section to another which are of infrequent occurrence nowadays, at least in the principal winter wheat growing regions, and have never been noteworthy except in the western districts.

The reason for the excessive damage by the various grain pests noted in this country is not hard to discover. Our system of growing the same grain crops over vast areas year after year furnishes at once the very best conditions for the multiplication of the insect enemies of such crops. In addition to this is the fact that America, with its long, hot summers, presents the most favorable conditions for the multiplication of most insects. These two reasons undoubtedly account for the far greater losses experienced in this country as compared with Europe, the summers of which are very cool and short. Furthermore, in Europe farming is on a much more intensive scale. The holdings are small and carefully inspected, and any insect outbreak is promptly taken hold of, and in addition to this a regular system of rotation of crops is often practiced.

The losses occasioned by the insects mentioned above exhibit a wide range in different years, due as a rule to favorable or unfavorable climatic conditions, and also to the abundance from time to time of the parasitic and other enemies, which is a natural sequence of the multiplication of the host insects. This results in a more or less striking periodicity in the recurrence of the common grain pests. Fortunately in many instances these periods of unusual abundance are separated by wide intervals of comparative freedom. Sometimes, also, a season which is unfavorable for one insect is favorable for another. Hence we have not only a periodicity in the recurrence of the same insect, but a more or less marked rotation of the different species. All of this emphasizes the need on the part of the wheat grower of a thorough acquaintance with these different insect enemies, and with the climatic and other conditions which are liable to promote their abundance, and especially with the measures which may be taken to prevent or limit loss.

The annual losses resulting from the attacks of these several insects on wheat is undoubtedly very great, running far into the millions in bad years, no very considerable percentage of which is made good by the enhanced value of the remainder of the crop. Much of this loss can undoubtedly be prevented by proper attention to cultural methods and the adoption of known remedies.

In the accounts of the chief wheat pests which follow, an effort has been made to give a brief presentation of the life histories of the several species treated, with special reference to the bearing of remedial and preventive measures.

THE CHINCH BUG.

(*Blissus leucopterus* Say.)

The chinch bug (fig. 1) is certainly responsible for as great annual losses to farm crops as any other injurious species of insect known, and it is very improbable that any other species causes anything like the damage which is chargeable to this pest. This is due to its wide distribution, its prevalence more or less every year, the enormous multiplication in favorable seasons, and to the fact that it attacks all the cereals and most forage plants. The losses caused by it vary greatly in different years, but are always experienced more or less in some locality or other. These losses may often amount to a very large percentage of the wheat and other cereal crops, and also later of the corn crop, and throughout the season of various forage crops. The losses for single States in one season have been estimated at from ten millions to twenty millions of dollars, and for single years throughout its range at above a hundred million dollars. Large as these figures are, when the actual estimates of shrinkage of yield of wheat and

other grains, not to mention forage crops, are made, it will be seen that they are reasonable and probably within the true amount. Much of this loss undoubtedly can be avoided by a proper system of farm management and the adoption of known methods of control.

The important natural agencies responsible for the abundance or scarcity of this insect are not insect parasites, for it has none of any importance, but unfavorable climatic conditions and the various diseases induced thereby. The chinch bug is notably an accompaniment of drought, and very rarely, if ever, is serious injury caused by it in other than dry seasons. Wet weather is very prejudicial to it and develops various fungous diseases, which as a rule very promptly result in its practical extermination for the season. Unfortunately these weather conditions are not subject to control, and the chinch bug, therefore, is bound to be in evidence in dry years. It then becomes a matter of attention to whatever practical farm methods are available to prevent greater loss than necessary.

Distribution.—The chinch bug is a native insect, originally subsisting on various wild grasses in the Mississippi Valley and throughout its range. On this continent it is widely distributed (fig. 2), occurring from Nova Scotia and Manitoba southward to the Gulf. It occurs also in California, Lower California, and in Mexico and Central America, and also on several of the West Indian Islands. Over much of this area it is not often very injurious, and the chief losses occasioned by it are in the Ohio and Upper Mississippi Valley and lake region, and, to a less extent, northeastward throughout the Allegheny region, New England, and Nova Scotia. The Gulf States do not so often suffer serious injury from this insect, except occasionally, perhaps, in the rice-growing regions.

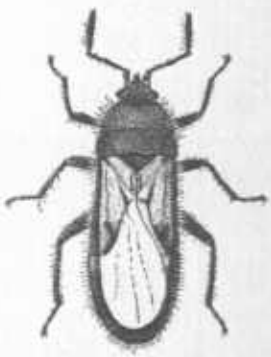

FIG. 1.—Chinch bug (*Blissus leucopterus*) adult of long-winged form, much enlarged (from Webster).

The losses resulting from the chinch bug are largely to the wheat crop, and it is one of the most important wheat pests. The losses to corn are almost always a result of migrations from wheat fields after harvest. The losses to grasses are less noticeable, although in some cases quite important.

Attention was first drawn to its ravages in the latter part of the last century, and the records of notable outbreaks and serious loss have been pretty constant since 1800.[1]

[1] A matter of no especial importance is the fact that along with the ordinary chinch bug, which is winged and capable of strong flight in the adult stage, there frequently occurs, especially in maritime districts, both of the Atlantic coast and the Great Lakes, a short-winged form (fig. 3), the wings of which vary from almost nothing to nearly full size. This short-winged form is associated with the normal type, and has the same habits except that it is not capable of flight. So far as the practical consideration of this species is concerned, the short-winged form may be ignored.

a, Area s in the United States over which the chinch bug occurs in most destructive numbers (from Webster).

b, Shows where chinch bug is found in the United States, but not in most destructive numbers.

FIG. 2.—Map showing distribution of chinch bug in the United States.

From the standpoint of control no feature of the life history of this insect is so important as its overwintering habit. The general belief has been that the species hibernates beneath rubbish, such as old straw, or matted grass, or leaves in hedge rows, and this is probably often the case to a certain extent, but undoubtedly the normal place of hibernation is in the dense stools, especially of wild grasses, and also of such cultivated grasses as incline to the stooling habit.

Autumnal flight.—Toward the last of September the chinch bug begins its autumnal flight, and very shortly thereafter disappears entirely from the fields of corn or other late crops. In this flight it frequently goes some distance from the fields which it has infested, and, finding in these grass stools favorable situations, works its way well down into the stool, almost or quite beneath the surface of the ground, or into the soil which has been caught and held by the dense bunches of grass. In these situations chinch bugs may be found during

FIG. 3.—Chinch bug (*Blissus leucopterus*) adults of short-winged form—much enlarged (adapted from Webster).

the winter, a single grass stool frequently harboring hundreds of insects. So marked is this hibernating habit that it is reasonable to infer that it is the normal and ancient one of the species, the natural food plants of which before the advent of settlement and the growth of cereals were these same native grasses. Where cultivation has destroyed these grasses, and the chinch bug is no longer able to find such localities for winter concealment, it undoubtedly hibernates under rubbish and in the other situations suggested. The bearing of this hibernating habit on remedies will be noted later.

Life cycle.—The annual life cycle of this insect may be exhibited by the following summary, based on a careful study, made by the writer in eastern Kansas. The dates given will hold for the middle region occupied by this insect, but northward there will be a retardation, and southward an acceleration, in the times of appearance and the development of the different broods.

April 10–20, spring flight from hibernating quarters in grass stools to wheat fields.
April 20–30, *in coitu* about the roots of wheat.
May 1–31, deposition of eggs on wheat roots beneath the surface of the soil, with young hatching from May 15 to June 15.

July 1–15, maturing of the first brood, followed immediately by the midsummer flight, if a migration of immature and adult forms has not been previously occasioned by the harvesting of grain or the local failure of the food supply.

July 15–30, union of the sexes and deposition of eggs in the soil about late corn or millet, the young of this brood appearing in maximum numbers about August 5.

August 20 to September 10, maturing of the second brood and partial flight of same to late corn or other green crops if in fields of corn already mature and dying.

September 15 to October 15, autumnal flight to grass lands and concealment in grass stools for hibernation.

Different stages.—The chinch bug goes through six different stages, from the egg to the adult insect. The egg is less than three-tenths of an inch long, cylindrical, and squarely docked at one end, in color pale or whitish when first deposited, but later showing the colors of the developing embryo through the shell. The newly hatched larva (fig. 4) is but little larger than the egg and resembles the adult insect in miniature except in having no wings. It is of a pale reddish color, with a yellow band across the first two abdominal segments. The second larval stage resembles the first except in being larger, and having the head and thoracic segments dusky and hardened. After the second molt there is again an increase in size, and the head and thorax become still darker and more coriaceous. The next molt introduces the pupal stage of the insect, which resembles the adult almost exactly, except that the wings are replaced by mere wing pads, which latter had already been foreshadowed in the last larval stage. The next molt results in the perfect insect. Nearly two months are required to complete this life cycle.

FIG. 4.—The chinch bug (*Blissus leucopterus*): *a*, *b*, eggs; *c*, newly hatched larva; *d*, its tarsus; *e*, larva after first molt; *f*, same after second molt; *g*, pupa—the natural sizes indicated at sides; *h*, enlarged leg of perfect bug; *j*, tarsus of same still more enlarged; *i*, proboscis or beak, enlarged (from Riley).

After hatching the chinch bug is extraordinarily active in all stages, even the minute larva being able to travel rapidly and to extract itself from a considerable depth of covering soil if necessary.

Habits.—In habits this insect is distinctly gregarious, associating itself in masses on the plants attacked, commonly going by preference to the lower portions of the plant and, in the early larval stage, even working on the superficial roots.

Migration.—The first brood is normally developed in wheat land, for the simple reason that when the chinch bug takes its spring flight wheat is the growing crop which is most likely to attract it. The wheat crop matures and is harvested, as a rule, before the first brood of bugs has reached maturity or at about the time they are entering the adult

stage. The ripening and harvesting of the grain deprives them of food and induces a migration, and the young, half-grown, and adult insects start off together, apparently with a common impulse, abandoning the wheat fields and attacking any near-by cornfield or grass field. Their travels, while commonly much less, may extend to a distance of a quarter of a mile or more, and, as a rule, under these circumstances the bugs are numerous enough to completely carpet the ground. Entering a field of corn, they congregate on the outer rows at first, fairly blackening the stalks with their bodies and absolutely killing the corn as they move inward. As a rule, the serious damage is on the edge of the cornfields, sometimes, however, extending inward several rods.

If this midsummer migration is not induced by the harvesting of grain, or where the chinch bugs develop in other situations, their reaching maturity is immediately followed by midsummer flight to corn or millet or other crop.

Crawl on ground.—Curiously enough, in the migration above noted the winged individuals, as well the wingless, all crawl together on the ground, and flight seems never to be attempted on the part of the adult. The second brood, maturing about the last of August and the first of September, may have a partial flight to late corn or other late crops if the cornfields in which they develop have already matured and are drying up, but between the middle of September and the first of October they take what may be termed the autumnal flight to grass lands or other situations for concealment and hibernation.

PREVENTIVES AND REMEDIES.

For the practical control of the chinch bug many suggestions have been made, some of which have a good deal of utility. These are considered in the order of their importance.

(1) **Burning over waste land.**—The hibernating habit of the chinch bug suggests at once the advisability of burning over and clearing up all waste land where this insect would be apt to congregate for overwintering. The burning of grass lands, especially the wild grasses which may have the stooling habit, should be done early in the fall so as to expose the chinch bugs that may not be killed by the flames as long as possible to the unfavorable action of the cold and freezing of winter. All the rubbish in the fence corners and hedge rows should be raked out and burned and as little material left as possible for protection of the insects. Cultivated meadows may be safely burned over when the ground is frozen without injury to the grass.

(2) **Trap crops.**—The planting of trap crops has been suggested and may occasionally be of some value. Of this nature is the early planting of patches of millet or Hungarian grass or spring wheat to attract the chinch bugs in the first spring flight. Such land after becoming

infested should be turned under with the plow and not planted until late in the season to other crops. The eggs thus buried will hatch in the soil, and, as a rule, the young insects will find plenty of avenues of escape; but if there be no near-by crops, they will ultimately perish, since they are unable to travel far at this stage. In the same way trap crops may be planted between wheat and corn to protect the latter from the migrating bugs from wheat fields after harvest.

(3) **Rotation.**—If a system of rotation could be adopted which would entirely disassociate small grains from corn, very little damage from the chinch bug would ever be experienced, at least to the latter crop. Following out this idea would mean the planting of a farm to corn one year and to wheat and small grains the next or some similar system of rotation.

(4) **Plowing as a check.**—In checking the midsummer migrating bugs some good may also be done by turning under the first rows of corn or other crop attacked. To have any practical value, however, the plowing must be done very deeply, or many of the bugs will escape.

(5) **Spraying.**—The first rows attacked by the bugs may also be sprayed with a very strong oily insecticide, such as kerosene emulsion—a mixture strong enough even to kill the corn itself and the bugs along with it.

(6) **Protecting furrows.**—The making of protecting furrows, as recommended for the army worm, is also applicable to the chinch bug. The bugs which collect in the furrow may be killed either by dragging a log along or by thoroughly wetting with the kerosene and water mixture.

(7) **Coal-tar barriers.**—A good deal of effort has been made in some places to protect fields by placing about them lines or barriers of coal tar. Where this is done the line of tar must be renewed several times a day. At intervals along it holes may be bored, in which the bugs will accumulate and may be destroyed. All that is necessary is to put a single straight line of tar in front of the migrating bugs and make holes on the side of attack with a post auger at distances of 8 or 10 feet close to the tarred line. Various other forms of barriers will easily suggest themselves, such as putting a line of boards about a field and smearing it with tar or combining the tar with the furrow method.

Promptness and vigilance are the essentials in any of these remedial operations.

(8) **Control by fungous diseases.**—A great deal of work has been done of late years in the use of various fungous diseases as a means of controlling the chinch bug. It was early observed that the chinch bug was frequently exterminated by a disease, and the idea naturally suggested itself that this disease could be collected and disseminated at the proper time and result in quick riddance from this pest. Appropri-

ations for experimentation with this disease have been made by various States, notably Illinois, Kansas, and Wisconsin, and the value of this method of control has been thoroughly tested by trained experts. The upshot of all this work has been to show that this agency of control is not of very great value. In other words, as already pointed out, unusual chinch-bug increase and damage are characteristic only of seasons of drought, and, unfortunately for the use of the diseases mentioned, they are propagated successfully and are effective only under conditions of considerable dampness or following a wet period. The very conditions, therefore, which make the disease useful are inimical to the chinch bug and, as a rule, exterminate it without the artificial introduction of the disease germs. In fact, it seems to be pretty well established that the disease occurs very generally, doubtless attacking other insects besides the chinch bugs, and whenever the weather conditions are favorable it develops itself and accomplishes the destruction of the chinch bug without the necessity of artificial introductions. It is doubtless true that occasionally when the disease is introduced just at the beginning of a rainy spell it may take hold of the bugs a little more quickly and effect their extermination more promptly than would have been the case had no artificial infections been made. In the main, however, it is scarcely worth while to bother with or rely on the introduction of this disease. If suitable climatic conditions intervene, the disease probably will itself develop and the chinch bugs will disappear. If, on the other hand, droughty conditions prevail, the introduction of the disease will be of no service.

The immature bugs seem to be especially susceptible to the action of this disease, the mature insects being much more rarely affected by it.

Summing up the subject of preventives and remedies, it may be said that the ones of real value are the clearing of farms and adjacent lands of rubbish and deadened grass by burning, the adoption of a rotation of crops which will separate the small grains from the later-ripening crops such as corn and late-sown millet, and the adoption of the steps indicated to stop the migrating midsummer hordes.

THE HESSIAN FLY.

(*Cecidomyia destructor* Say.)

Economic importance and general characteristics.—The Hessian fly (fig. 5) is one of the principal enemies of the wheat crop, the minimum annual damage due to it being estimated at about 10 per cent of the product in the chief wheat-growing sections of this country, which indicates an annual loss of 40,000,000 bushels and over. An injury of from 50 per cent to a total failure of the crop is not infrequent in certain localities, and the resulting loss is proportionately greater.

The parent insect is a very fragile, dark-colored gnat or midge,

about $\frac{1}{8}$ inch long and resembling somewhat closely a small mosquito. As commonly observed, however, more or less hidden in the base of young wheat plants or other small grains, the insect appears either in the form of a footless maggot, or larva, or in what is known as the flaxseed state, which corresponds to the chrysalis of other insects. The injury to the plant is done altogether by the larva, which feeds on the tissues and juices and weakens and eventually destroys the plant.

Distribution.—In common with many other of our more injurious farm pests, the Hessian fly is an importation from Europe; and the evidence points very strongly to the fact of its introduction in straw brought over with the Hessian troops during the war of the Revolu-

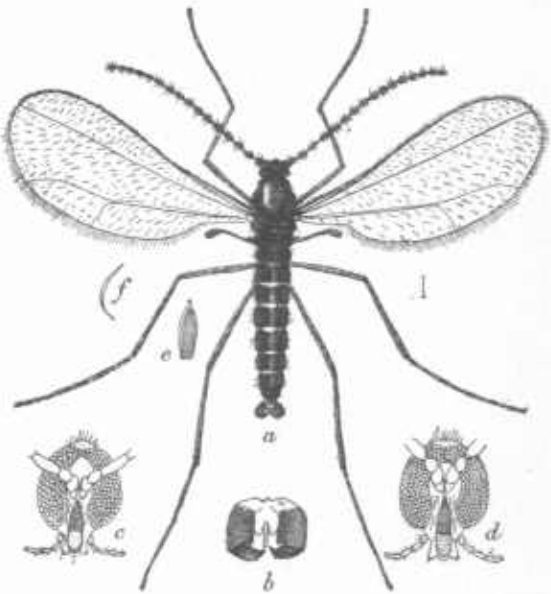

FIG. 5.—The Hessian fly (*Cecidomyia destructor*): *a*, male; *b*, enlarged anal segment of same; *c*, head of female; *d*, head of male; *e*, scale from leg of male; *f*, scale from wing; all greatly enlarged (original).

tion. It first appeared in injurious numbers in 1779 in the vicinity of the landing place of these troops three years before on Long Island, and has gradually spread westward, following the movement of settlement and wheat culture, reaching the Pacific slope about 1884, and now practically extends throughout the wheat belt of the United States and Canada. It has long been known on the continent of Europe, covering the wheat belt from Russia westward. It appeared in England in injurious numbers in 1886 and was first thought to have been recently introduced, but has since been proved to have been present long before in barley fields. In 1888 it was reported from New Zealand and has since become an important grain pest there, thus nearly completing the circuit of the globe.

Natural history and habits.—The Hessian fly is distinctively a wheat insect, but will breed also in barley and rye. What has been taken for this insect has, in recent years, been found occasionally in timothy and several wild grasses, but the insects in these cases are now known to be distinct from the Hessian fly, and the occurrence of the latter in plants other than those first named is extremely doubtful.

Over the bulk of the wheat area of the United States there are two principal broods of the Hessian fly annually, viz, a spring and a fall brood. There are, however, supplemental broods, both in spring and in fall, particularly in the southern wheat areas, but in the extreme northern area of the spring wheat belt there may be only a single

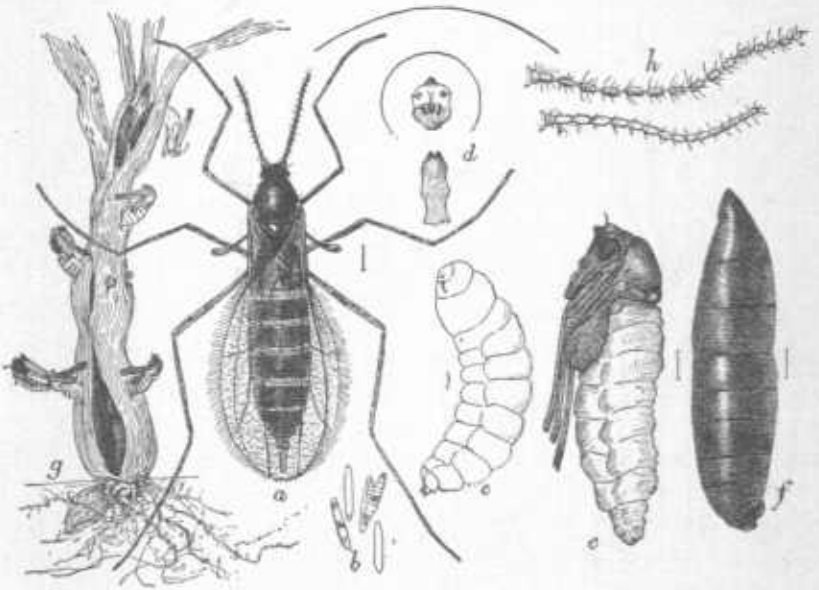

FIG. 6.—Hessian fly (*Cecidomyia destructor*): *a*, female fly; *b*, flaxseed pupa; *c*, larva, *d*, head and breastbone of same; *e*, puparium; *f*, cocoon; *g*, infested wheat stem showing emergence of pupæ and adults (original).

annual brood, the progeny of the spring brood passing the late summer and the winter in the flaxseed state instead of developing a brood in autumn. It is possible, however, that in this region an autumn brood may develop in volunteer spring wheat.

Each generation is represented by four distinct states, viz, (1) egg, (2) maggot, or larva, (3) pupa, or flaxseed, and (4) mature winged insect.

The eggs are very minute and slender, pale red in color, and are usually deposited in regular rows of 3 to 5 or more on the upper surface of the leaf. In the case of the spring brood they are sometimes thrust beneath the sheath of the leaf, on the lower joints. The number of eggs produced by a single female varies from 100 to 150.

The whitish maggots hatch in from three to five days and crawl down the leaf to the base of the sheath, embedding themselves between the sheath and stem, and develop on the substance of the wheat, causing more or less distortion and bulbous enlargement at the point of attack (figs. 6, 7).

In a few weeks the larva contracts into a flaxseed-like object, which is the puparium. In the case of the spring brood the insect remains in the flaxseed state during midsummer, yielding the perfect insect for the most part in September; in the case of the fall brood the winter is passed in the base of the wheat in the flaxseed condition.

The fall brood works in the young wheat very near or at the surface of the ground. The spring brood usually develops in the lower joints of the wheat, commonly so near the ground as to be left in the stubble on harvesting. With spring wheat the attack is sometimes just at the surface of the ground, as in the case of the fall brood. The adults from the wintered-over flaxseed puparia emerge during April and May, most numerously before the middle of the latter month. The adults of the important fall brood emerge chiefly during September.

FIG. 7.—Wheat plant showing injuries by Hessian fly: *a*, egg of Hessian fly; *b*, larva; *c*, flaxseed; *d*, pupa or chrysalis; *e*, female, natural size; *f*, female; *g*, male; *h*, flaxseed between the leaves and stalk; *i*, chalcidid parasite—all enlarged except wheat stem and fig. *e* (after Riley, Burgess, and Trouvelot).

There is a supplemental spring brood following the main one and a supplemental fall brood preceding the main one. These supplemental broods are, as a rule, comparatively unimportant, most of the individuals of the spring and fall broods going through the course of development first indicated. Under any favorable weather conditions, as indicated further on, the supplemental fall brood may become a very important one, as illustrated by the season of 1899–1900 in the Ohio valley.

Exceptionally also, this insect may remain dormant in the flaxseed state for a year or more and still bring forth the adult, a provision of nature which is doubtless intended to prevent the accidental extermination of the species. The migrating and scattering brood of adults is the one developed in the fall; the spring brood is less apt to scatter from the field in which it is developed.

The important feature in the life history of the Hessian fly from the

standpoint of control is the time of emergence of the fall brood or broods of adults. This arises from the fact that the chief means of preventing loss from this insect is in sowing late enough in the fall to avoid infestation. For the average season or normal conditions dates at which sowing is comparatively safe have been determined for the principal winter wheat districts. For example, the dates after which sowing may be safely undertaken in the State of Ohio, as shown by the very careful investigations of Professor Webster, vary over a period of at least a month from the northern latitudes of the State to the southern latitudes, or from approximately September 10 in the north to October 10 in the south. Wheat sown after the dates mentioned, or after intervening dates for intervening latitudes, will germinate in normal seasons after the Hessian fly has disappeared and be free from attack.

The question of latitude, however, is not the only one to be considered, since temperature is affected also by altitude, and in mountainous States like West Virginia, as shown by the very careful studies of Dr. Hopkins, the altitude must be taken into consideration in determining the proper date for planting. The normal safe date for planting must be determined for each locality separately. Ohio farmers are referred to Bulletin No. 119 of the Ohio Experimental Station, by F. M. Webster, and West Virginia farmers to Bulletin No. 67 of the West Virginia Experimental Station, by A. D. Hopkins.

Unfortunately, also, it is not possible to give a uniform date for seeding which may be relied on year after year. The extraordinary development of the Hessian fly and the serious consequent losses to the crop of 1899–1900 have emphatically demonstrated this fact. The loss from the Hessian fly for the crop mentioned has been one of the worst in the history of this insect in America and probably amounted to fully 80 per cent of the normal yield throughout the infested region (fig. 8) which covered the main winter wheat districts of the Ohio Valley and amounted to a loss of from thirty-five to forty millions of dollars worth of grain. The extraordinary multiplication of the fly for the season indicated resulted from an unusual scarcity of the parasitic enemies of the insect and a series of very favorable weather conditions, the latter, as indicated by Professor Webster, being the long drought of the autumn of 1899 which prevented the normal early hatching of the Hessian fly, and the mild autumn and winter following which enabled the insects to continue breeding and ovipositing much later than is ordinarily the case, so that few fields escaped fall infestation. A favorable winter carried these insects through safely, and the enormous number of flies which emerged for the spring brood resulted in all late sown or other fields which had escaped the fly in autumn

being infested by hordes of these insects in the spring. In other words, under the conditions of the season in question all the ordinary rules and preventives failed absolutely and the loss of the wheat crop was almost total.

Unfortunately, similar conditions threatened the growing crop (1900–1901). The enormous abundance of the flies and a late and very mild autumn have resulted again in an extraordinary infestation by this insect over large areas.

The breeding of the Hessian fly during the autumn of 1900 continued in some localities very late. Mr. E. P. McCaslin, Seymour, Ind., who has been making very careful study and frequent reports on this insect for this office, supplies data showing that the wheat sown

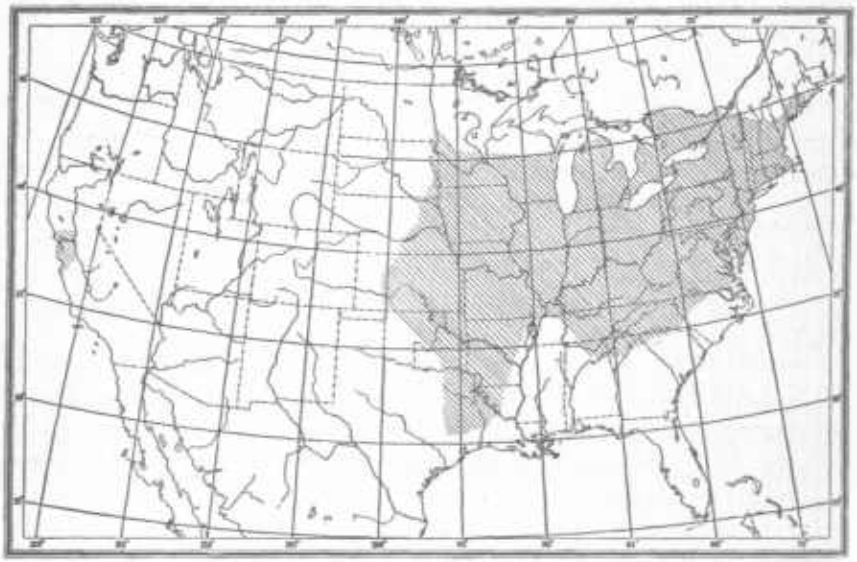

FIG. 8.—Map showing distribution of Hessian fly in America (reduced from Webster).

in that locality between October 9 and 15 was badly infested by the fly. The insect began hatching as early as the 1st of September and continued in evidence until the 1st of October, a supplemental brood appearing after October 22. The winter was so mild that undeveloped larvæ were abundant in wheat into the second week of December. A short period of zero weather in the middle of December did not destroy the larvæ (fig. 9), but a prolonged cold spell beginning about December 22 killed most of the larvæ that had not passed into the flaxseed stage. That the insect will hatch from the flaxseed stage without long hibernation if kept in a warm place was illustrated by material coming into this office which yielded flies in great numbers during January and February and deposited eggs from which young larvæ emerged.

The effect of drought on the Hessian fly was very interestingly

shown by the season of 1899-1900. As pointed out by Professor Webster, a severe dry spell sufficient to prevent the germination of wheat, such as was experienced in the Ohio valley in the fall of 1899, will retard the development of the Hessian fly; but a week or ten days after a drenching rain, following such a dry spell, flies will come forth from the flaxseed stage in numbers. All of these conditions, therefore, must be borne in mind in attempting to determine when it is safe to sow winter wheat, and when the conditions are very unfavorable it will probably be wiser to plant other crops than those which the Hessian fly infests, as indicated in the consideration of preventives and remedies.

Effect on wheat.—The first indication in the fall of the presence of the fly in wheat is the much darker color of the leaves and the tendency to stool out rather freely. This is very noticeable, and gives the wheat for the time being a very healthy appearance. The leaves are also broader, but the upright central stems are wanting, having been killed by the fly. Later, the infested plants turn yellow or brown and die in part or altogether.

The spring brood of larvæ attacks tillers or laterals that have escaped the fall broods, dwarfing the stems and weakening them so that they usually fall before ripening and can not be successfully harvested.

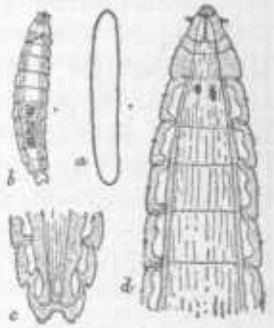

FIG. 9.—Hessian fly (*Cecidomyia destructor*): *a*, egg; *b*, larva newly hatched; *c*, anal segments of same; *d*, anterior segments—*a*, *b*, enlarged; *c*, *d*, greatly enlarged (original).

The excessive stooling, or tillering, of wheat attacked by the fly is doubtless due to the natural tendency on the part of the plant to offset the injury by forming new lateral stems, and therefore a wheat that has a natural tendency in this direction is less apt to be seriously damaged by the fly. Other things being equal, also, wheat with stiff, flinty stems is less damaged by fly attack, chiefly because the straw does not bend or break so readily at the point weakened by the spring brood of larvæ.

Natural enemies.—The Hessian fly in the larval and pupal periods is subject to the attacks of important natural parasites—small four-winged flies which develop within the bodies of their hosts. There are several native parasites, and in Europe there are many others, one of which is remarkably prolific, and the Department has attempted its artificial introduction into this country. This species, *Entedon epigonus*, has been liberated in several States, and seems to have obtained a foothold, and considerable good may be expected from it.

In general, the parasites are effective only in limiting damage and are useful where other preventives are neglected, but can never take the place of active measures where perfect immunity is desired.

PREVENTIVE AND REMEDIAL MEASURES.

It is practically impossible to save a field once severely attacked by this fly, and under such circumstances it is better to plow the wheat under deeply and plant to corn or other spring crop.

In cases of mild infestation, the best procedure is the prompt use of fertilizers, which may enable the wheat to tiller sufficiently to yield a partial crop. Pasturing in fall of early-sown fields is also recommended, and may do some good by reducing the numbers of the pests.

Somewhat in line with pasturing of early-sown fields is an interesting experiment made in the spring of 1900 by Mr. E. P. McCaslin. Finding that the flies were ovipositing abundantly on wheat which had reached a height of 6 or 8 inches, he conceived the idea of cutting it off closely with a mowing machine as soon as all the eggs of a spring brood had been deposited, keeping close watch to determine the proper moment. The theory was that the severed tops of the wheat with attached eggs would dry up in a day or two, and the larvæ, not being able to move freely except down the green leaf blades, would fail to reach the live stubble. Wheat so cut threw out new stalks and gave every promise of a good yield, but unfortunately for the success of the experiment, the fly was so extraordinarily abundant everywhere in the spring of 1900 that the stubble was reinfested and the experiment came to naught. Nevertheless, under a less extraordinary instance of general fly infestation, some benefit might reasonably be expected from the procedure, and it is perhaps worthy of further trial.

By some such means as the above a crop of wheat may be partly saved, but in the main the measures of really practical value against this insect are, of necessity, chiefly in the direction of preventing future injury. These are all in the line of farm methods of control, and are arranged in the order of importance as follows:

Late planting of winter wheat.—As already indicated in the paragraphs on habits and life history, late planting of winter wheat is undoubtedly the best and most practical means in normal seasons of preventing damage in regions where infestation is to be anticipated, and this is true in spite of the failure of this means of control during the season of 1899–1900. The most that can be advised under this head, however, is to give a general statement covering normal years and climatic conditions. The actual date after which planting may be safely made must necessarily be fixed for each locality separately, and be subject to yearly modification to meet varying seasonal conditions. In a general way, to avoid fly injury, planting should be made in the northern winter wheat districts after the 15th or 20th of September, and in the more southern districts between October 1 and 15. If the right time be selected, neither early enough to be attacked by the

fly nor yet so late as to cause danger of winter killing, much of the damage in normal seasons to winter wheat from this insect may be avoided.

Burning stubble.—The fact has been noted in the life history that the second brood develops in the lower joints of the wheat and is left, for the most part, in the field in the flaxseed state at harvesting. All these individuals may be destroyed by promptly burning the stubble. Burning may be more easily effected if a rather long stubble be left, and especially if it be broken down by rolling. If the burning of the stubble be neglected until the rank growth of weeds has sprung up which usually follows harvest it will be well to run a mower over the fields, cutting off the stubble, weeds, and grass as close to the ground as possible, and burning over as soon as the weeds and grass dry sufficiently. Careful burning will very largely prevent an abundant fall brood of flies, and may be supplemented by burning all screenings of the wheat if thrashing preceedes the fall appearance of the fly.

Plowing under stubble.—In line with burning, and of nearly equal importance, is turning the stubble under by deep plowing, and afterwards rolling the field to compact the earth and prevent any flies which may mature from issuing.

Rotation of crops.—The regular practice of a system of rotation in the growth of crops is of the utmost importance in avoiding damage. Its value may be offset at times by invasion from neighboring fields of wheat on other farms, but usually comparative freedom from attack will result and the benefit will extend to the other crops coming in the system adopted in checking the insect enemies of these at the same time.

In seasons like that of 1899–1900, and possibly also 1900–1901, where the fly is very generally present, rotation of crops may fail very largely in being protective, and it may be even necessary to abandon wheat planting for a year over an entire county or State. Undoubtedly the Hessian fly can be starved out almost completely by the abandonment of the culture for one year of the crops in which it breeds, namely, wheat, rye, and barley, and occasions will probably arise again when this course will be advisable. To gain the full benefit of such a procedure all volunteer wheat, rye, or barley must be destroyed.

Trap or decoy plantings.—One of the earliest preventives recommended and one of considerable value is the early planting of narrow strips of wheat to act as decoys to attract the flies with the object of turning the infested wheat deeply under with the plow in late fall. This procedure will greatly reduce the numbers of the pest and should give greater immunity to late-planted wheat.

Destruction of volunteer wheat.—The supplemental fall brood antedating the principal brood will come to nothing if all volunteer wheat be plowed under or destroyed within a few weeks after its appearance.

This is of especial value in the North, where spring wheat is grown, and where the brood developed on the volunteer wheat may be the principal means of carrying the insect through the winter.

Growth of resistant wheats.—As indicated in the paragraph, "Effect on wheat," the importance of selecting varieties which are less injured by the attacks of the fly will be at once apparent. Such wheats are those having coarse, strong stems, and varieties which "tiller" freely or develop numerous secondary shoots. Among such wheats are the Underhill, Mediterranean, Red Cap, Red May, Clawson, etc. No wheats are, however, absolutely "fly proof."

THE WHEAT MIDGE.

(*Diplosis tritici* Kirby.)

The wheat midge (fig. 10) is another dipterous enemy of wheat, allied to the Hessian fly and the wheat bulb-worm by belonging to the same order of insects, but is entirely distinct in appearance and habit. It

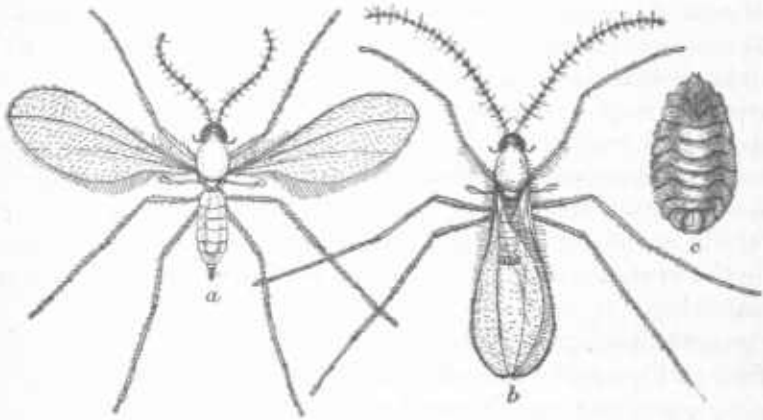

FIG. 10.—Wheat midge (*Diplosis tritici*): *a*, female fly; *b*, male fly; *c*, larva, ventral view—all enlarged (original).

is believed to be identical with the notorious wheat midge of England and the Continent of Europe, and might easily have been brought to this country, as was probably the case, with straw, as was the Hessian fly, or in soil from infected districts. According to Fitch, it was probably first introduced into the Province of Quebec and passed down through the New England States into New York, and has thence spread westward throughout the Mississippi Valley. The adult insect is a very minute gnat or midge, not exceeding one-tenth of an inch in length, and varying in color from orange to yellow, but tarnished or slightly smoky tinged on the back above the wings.

Injury by larvæ.—The injury occasioned by this insect to wheat and allied grains is by its orange-yellow larvæ or maggots to the forming embryos in the wheat heads. The milky juice is extracted by these

larvæ from the young kernels without any apparent gnawing of the surface, causing the grain to shrivel and the heads to blight and be imperfectly filled. On occasions of unusual outbreaks of this insect the crop is sometimes completely ruined, and occasionally the losses over whole States have averaged from two-thirds to three-fourths of the entire yield, or amounting to many millions of dollars. Damage to this extent is, however, unusual, and the wheat midge, while ranking as one of the chief insect enemies of the wheat crop, is commonly much less dreaded than the Hessian fly or the chinch bug.

The period of attack of this insect in early summer depends very much on the season, being retarded by cold and hastened by warmth. Ordinarily the fly appears about the wheat by the middle of June, and is present depositing its eggs for two or three weeks. In wet seasons it may even remain in evidence until the middle of August. Dryness is inimical to it, and unusual moisture is very favorable for its operations. It is especially active on cloudy days and at night. Wheat grown in low, moist land is therefore more subject to injury, and if unusually dry weather prevails during the period when the fly is depositing its eggs, little injury is done to the wheat crop, and correspondingly a wet season at the same period is liable to result in greater loss on account of this insect.

Where they oviposit.—The exceedingly minute oval, nearly cylindrical eggs, pale red in color, are deposited singly or in clusters to the number of ten in the crevices in the wheat heads, most often at the extremity of the head, and usually in the crevices and openings which lead to the developing kernel. In about a week the eggs hatch, and the larvæ find their way at once to the kernel or germ.

Vitality of the larva.—The life of the larva is about three weeks. The full-grown larva is fairly robust, oval in shape, and has a length, when in a quiescent state, of about eight-hundredths of an inch. When in motion, it extends somewhat and tapers markedly toward the anterior extremity. It now abandons the wheat head and descends to the ground, either by skipping or jumping from the plant or crawling down the stem in a pellicle of water, being practically amphibious. Many of the larvæ are still in the wheat heads when it is harvested and are carried away from the field when the wheat is stacked. Their vitality under these circumstances, as reported by Fitch and others, is something extraordinary, being able to survive for months without moisture or food. Those that enter the ground in the fall form minute cocoons not larger than a mustard seed, and when covered with dirt, as they usually are, are almost impossible of discovery. It is believed that they remain unchanged in the ground until the following spring, or probably until shortly before the appearance of the adult insect again in the wheat fields in June.

PREVENTIVES.

This insect is another one of the grain pests the ravages of which are not subject to immediate remedy in the field. The only steps of importance are in the line of prevention of future injury. A practical preventive suggested by the hibernating habit of the insect is in the deep plowing of the old wheat fields to bury the larvæ so deeply in the ground that they can not escape the following year. As a further preventive, the chaff and screenings from the thrashings of wheat from an infested field should be promptly burned. The practice of rotation of crops is also applicable to this species and will be of value in proportion to the isolation of the fields or to the generality of its adoption.

THE WHEAT PLANT-LOUSE.

(*Nectarophora cerealis* Kalt.)

This plant-louse (fig. 11) is not one of the principal insect enemies of the wheat crop, but in some years, fortunately widely separated, it multiplies in enormous numbers and over wide regions, and becomes almost as destructive and occasions almost as much loss as does the Hessian fly or the chinch bug. Such periods of extensive damage were witnessed in 1861 and again in 1899. Local damage is of more frequent occurrence, and the species, in fact, occurs every year more or less, and often arouses fears which, for reasons to be subsequently explained, are not realized.

Origin.—This insect is believed to be of European origin, and is the *Siphonophora avenæ* of Riley and other authors, a common wheat pest of the Old World. There are, however, at least two other forms of plant-lice of similar habits in this country, and one of these is believed to be a native American species closely allied to the European one under consideration. The question of its origin, however, does not have much practical bearing on its present economic status in America, since it now occurs on this continent practically wherever wheat is grown. One of the other plant-lice occurring on wheat, *Nectarophora granaria* Kby., known as the grain plant-louse, is sometimes nearly or quite as bad a pest as the species under discussion. In fact, almost any plant-louse that normally attacks the various wild or cultivated grasses or even other plants may occasionally occur in wheat. The habits of these other species which may sporadically appear on wheat are substantially identical with the one under discussion, and they need not be separately considered. Even the apple-tree plant-louse, *Aphis mali*, is occasionally found in wheat fields, and this has led to an erroneous belief in some quarters that this insect and the wheat-louse are the same species and that the winter eggs of the former, which often thickly cover apple twigs, develop the spring generation of lice which appears on wheat in April. The absurdity of this point of view is

evident from the fact that the apple-tree aphis and the wheat plant-louse belong to distinct genera.

When it appears.—The wheat plant-louse appears on winter wheat in September in the form of wingless females, which rapidly reproduce themselves, going through several generations. It occurs about the base of the wheat and on the roots, remaining in evidence as late as September 30. During the fall this louse does little damage to wheat growing in good, fertile soil, and after the lice leave, the plants, as a rule, soon recover. On poor soil, however, wheat may be seriously injured at this season. The method of over-wintering has never been discovered, but it seems probable that it hibernates on the wheat in the egg stage. At any rate, the wingless female lice reappear on the wheat early in April and remain in evidence, passing again through many generations, until harvest. Throughout the spring and early summer it works on the stems and leaves above ground. Later it moves to the wheat heads, and very frequently these are simply filled with clustered masses of lice, which now assume a brownish-orange color.

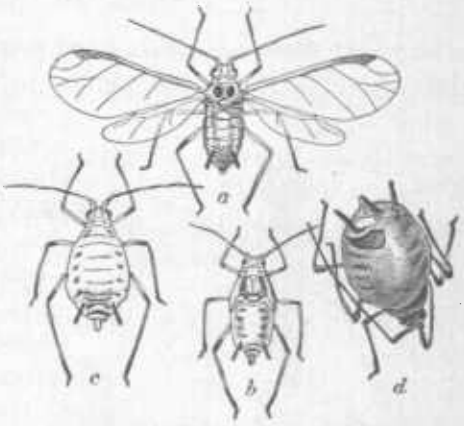

FIG. 11.—Wheat plant-louse (*Nectarophora cerealis*): *a*, winged migrant; *b*, nymph of winged migrant; *c*, wingless parthenogenetic female; *d*, wingless female, showing exit hole of parasite—all enlarged (adapted from Riley).

Natural enemies.—Fortunately this species has many natural enemies, including various insect-feeding beetles and flies and also true internal parasites (minute four-winged flies). These predaceous enemies and parasites, in connection with other natural agencies, particularly unfavorable weather conditions, are ordinarily sufficient to prevent undue multiplication.

Cause of outbreaks.—The reasons for the periods of excessive abundance or occasional outbreaks of this insect are not always easy to point out, but as a rule such outbreaks are due to the occurrence of unusually favorable climatic conditions. A rainy and fairly cool spring and early summer is favorable to the plant-louse, because, while not checking its own multiplication to any degree, and, in fact, favoring it, the conditions described prevent its predaceous and parasitic enemies from operating to any extent. As a rule, therefore, the drier and warmer weather commonly preceding harvest enables these natural enemies to gain the upper hand and quickly exterminate the lice, and this is commonly accomplished soon enough to prevent material damage to the crop.

NO REMEDY.

No remedy is possible in case of attaek by this insect, sinee direct application of insecticides to growing grain is out of the question, and there are no mechanical means of destroying the liee. One can only await the providence of the weather conditions and the action of natural enemies. As already pointed out, in the great majority of seasons, and often when the lice appear in the spring in numbers, unfavorable weather and the natural enemies effectually prevent appreciable damage.

THE WHEAT STRAW-WORMS.

(*Isosoma tritici* Fitch.)
(*Isosoma grande* Riley.)

The wheat stems or culms are subject to the attaeks of the larvæ of eertain minute insects belonging to the parasitie groups of the order Hymenoptera, which is represented by the parasites of the Hessian fly, plant-liee, etc. This little group or subfamily to which these wheat species belong has diverged from the great mass of its allies and acquired a strictly vegetable feeding or phytophagie habit instead of subsisting parasitically on other insects. Several of these species feed on wild and cultivated grasses, and several others on the various small grains. The two species which are especially destructive to wheat are known as the wheat straw-worm (*Isosoma grande* Riley) and the wheat joint worm (*Isosoma tritici* Fitch) (Fig. 12). The habits of these two insects are similar and result in similar injuries to the wheat crop, namely, weakening the stems or culms and causing them to break and fall before the grain is ripe, and at the same time weakening the plants and decreasing the yield. (Fig. 13.)

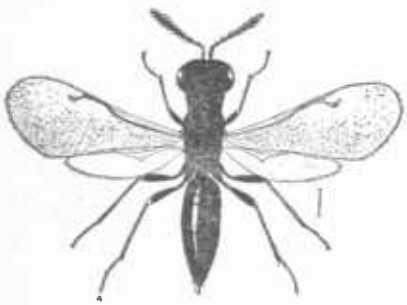

FIG. 12.—The wheat joint worm (*Isosoma tritici*): Adult fly, much enlarged (reduced from Howard).

FIG. 13.—Wheat stems, showing injury by joint worm (*Isosoma tritici*) (from Riley).

THE WHEAT JOINT WORM (*Isosoma tritici* Fitch).

This inseet was long confused with the joint worm of barley (*I. hordei* Harris), the habits of whieh it exactly duplieates. It is a true gall insect, its presenee being indicated by the oblong swellings or enlargements caused by the larvæ in the walls of the wheat stems. The galls are commonly found at or near the joints, and more commonly the second joint, but may occur in the vicinity of nearly every joint on the stem.

The adult insect is a minute black, four-winged fly, measuring in length from an eighth to less than a quarter of an inch, and closely resembles in appearance its own hymenopterous parasites and also the parasites of the Hessian fly and like insects. The galls usually occur in groups of three or four, and sometimes in large numbers together, greatly deforming and weakening the stem.

On cutting these galls open they will be found to contain when mature the joint worm larva, yellowish white in color, with its jaws or mouth-parts tipped with brown. In the larval and pupal stages this species resembles its ally, the straw-worm, *Isosoma tritici*. This species is believed to be single brooded, and to hibernate in its galls in the wheat stems in the larval stage, transforming to pupa and adult insect in the following spring or early summer.

THE WHEAT STRAW-WORM (*Isosoma grande*, Riley).

This insect (figs. 14, 15, 16,) is very closely allied to the joint worm.

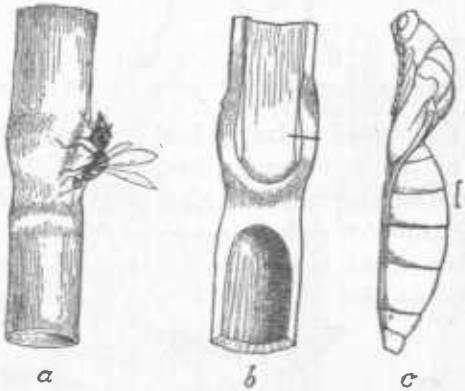

FIG. 14.—Wheat straw-worm (*Isosoma grande*); *a*, female inserting her eggs; *b*, section of wheat stem showing point reached by oviposition; *c*, pupa; much enlarged, *c*, more enlarged (after Riley).

It is distinguished, however, by its habit in living free within the hollow stems or culms of wheat, and producing no gall or deformation in the walls of the stem, as do the former species. Its work within the stem is indicated by the eaten and torn inner surface, and as a rule it does not occur in as great numbers as does the joint worm. It winters in the stem in the pupal stage instead of the larval stage, as does the joint worm, and is double brooded.

Difference in appearance of the two broods.—The adults of the two broods of this insect are quite dissimilar in appearance, and have been described as distinct species. The adults, consisting of both sexes coming from the over-wintered pupæ, are rather minute, and the females are wingless or with the wings greatly aborted and functionless. The eggs of this brood are deposited about the last of April or early in May near the embryo head of the wheat, which at this season

is only a short distance above the ground. These develop and produce the adult of the second generation in June. This generation is much larger and more robust than the spring generation, and consists entirely of females provided with fully developed wings. They are therefore capable of flying readily about and constitute the migratory brood.

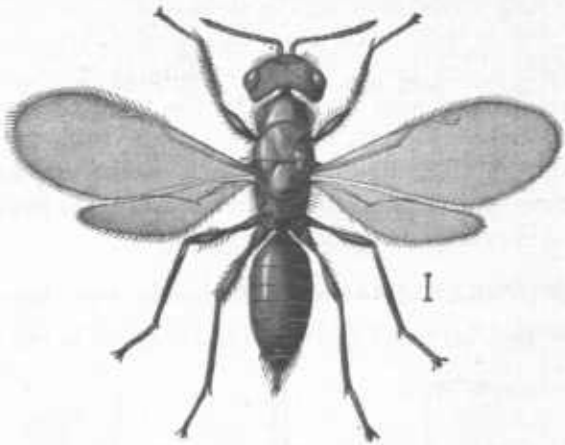

FIG. 15.—Wheat straw-worm (*Isosoma grande*), fall generation much enlarged (from Howard).

The eggs from this brood of large-sized females are deposited in or near the joints of the straw, more frequently near the second joint below the head. The worms on reaching maturity enter the pupal or chrysalis stage in the fall and emerge as adults the following spring.

Parasitic enemies.—Both of these insects are subject to the attacks of a number of parasitic flies which, as a rule, keep them pretty well in

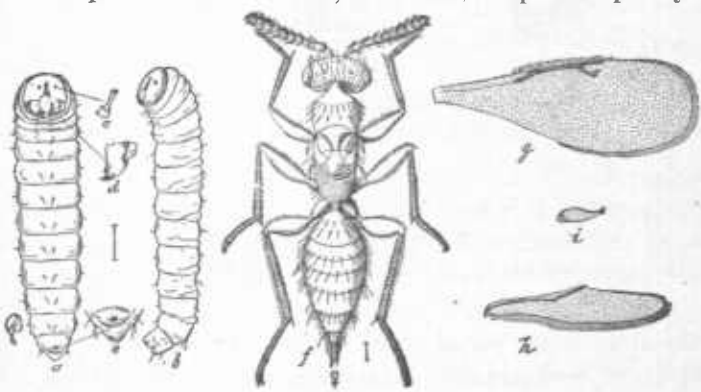

FIG. 16.—Wheat straw-worm (*Isosoma grande*), spring generation: *a*, *b*, larva; *f*, female; *g*, fore-wing *h*, hind-wing; all much enlarged (from Riley).

check. The damage from the wheat straw-worms is not often of a serious nature, but is quite general, and is probably very commonly overlooked on account of the concealed habits of the larvæ, and this is especially true of the wheat straw-worm, the falling of the grain being often attributed to other causes.

REMEDY.

The remedy for both of these insects is in burning the stubble which harbors the over-wintering stages. This burning may be done either directly after harvest or at any time during fall or winter, or prior to the earliest emergence of the adults, which may begin by the latter part of March.

THE WHEAT BULB-WORM.

(*Meromyza americana* Fitch.)

The parent of the wheat bulb-worm (fig. 17) is a minute two-winged fly or gnat, not at all related to the Hessian fly, except in its habit of breeding in wheat and various grasses, and the damage due to it is doubtless very often confused with that done by the more dreaded species.

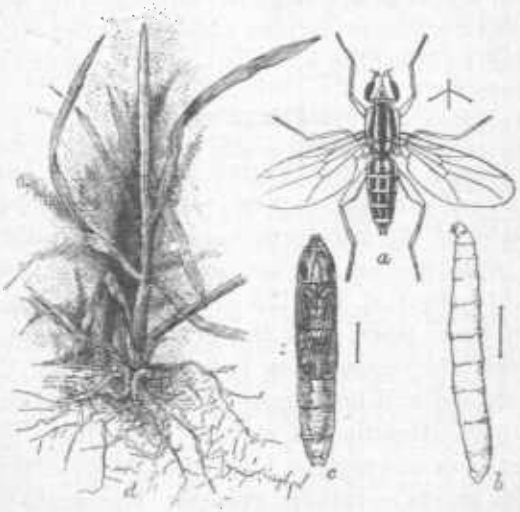

FIG. 17.—Wheat bulb-worm (*Meromyza americana*): *a*, mature fly; *b*, larva; *c*, puparium; *d*, infested wheat stem—all enlarged except *d* (original).

DISTRIBUTION.

The wheat bulb-worm fly is a native American species, and doubtless originally bred in various wild grasses. It is known to attack timothy and blue-stem and other grasses, and also rye, oats, and barley, as well as wheat. It is not nearly so destructive an insect as the Hessian fly, yet sometimes causes considerable loss. It is widely distributed, occurring from Canada southward to Texas, and practically covering the wheat belt of eastern North America. It works in the wheat very much as does the Hessian fly, developing at least three generations or broods in the latitude of Ohio, and perhaps one or more additional broods in Texas and the South. The flies appear in September and October and deposit eggs (less than 0.025 of an inch in length) on the

young wheat plants. The pale watery green footless maggots hatching from these eggs work their way down between the leaves to the crown of the plant and feed on the central part of the stem, cutting it entirely off and causing the central blade to discolor and die. These maggots pass the winter in the wheat, at the point indicated, and transform to pupæ in April and May and emerge as adults in June. An adult is about one-fifth of an inch long, greenish in color, and marked with three longitudinal black stripes on the back (thorax and abdomen). The eggs of this brood of flies are deposited, often several in a row, usually near the edge of the sheath of the upper leaf, so that the larvæ or maggots coming from them can readily penetrate the succulent portion of the stem just above the last joint, where they remain feeding on the stem and eventually killing it, causing the upper portion of the straw to wither and die and the head to blight or turn white. The second brood of adults escape from the straw in July and August and breed in volunteer wheat or various grasses, developing a third brood of adults in time to infest the winter wheat in September and October.

REMEDIES.

The chief remedy for the Hessian fly, namely, late planting of wheat, does not, unfortunately, apply to this closely allied pest, because the adult females of the latter are known to occur abundantly up to October. If grain can be thrashed promptly after harvest and the straw and stubble burned, it will doubtless effect the destruction of a great many of these pests, or if the grain be removed from the field as soon as practicable after being harvested most of the insects will be carried away and will not succeed in escaping from the center of the stacks at least. Rotation of crops as a preventive applies also to this insect, but even this remedy loses some of its value from the fact that the species breeds in various grasses. Fortunately, some important parasitic and predaceous insects usually keep this grain pest in check, and it is therefore unusual for it to assume a very injurious rôle, although widespread and frequently occasioning more or less loss.

THE ARMY WORMS.

(*Leucania unipuncta* Haw.)
(*Laphygma frugiperda* S. and A.)

Damage to wheat from the caterpillars commonly known as army worms and the injury caused by the allied cutworms, which come in the same category, is of such an intermittent or occasional character that the farmer can hardly be expected to take regular precautions to prevent the attacks of these insects. Severe injury is witnessed, as a rule, only at comparatively long intervals at a time in any one region, although injury probably occurs every year in some part of the coun-

try or other in varying amount. Where farms are carefully and cleanly cultivated, and not contiguous to waste or swampy land, and ground to be planted in wheat is early plowed, damage from these pests will not often be experienced.

The two worst depredators need only be discussed, namely, the army worm, *Leucania unipuncta* (figs. 18 and 19), and the grass worm, or fall army worm, *Laphygma frugiperda*.

FIG. 18.—Army worm, *Leucania unipuncta*, full-grown larva, natural size (from Comstock).

THE ARMY WORM.

(*Leucania unipuncta* Haw.)[1]

Serious army-worm outbreaks are most common in the months of May and June, or sometimes as late as July, when wheat, oats, and other small grains, corn, timothy, and various grasses, with the exception of clover, are occasionally suddenly overrun by multitudes of the dark-colored, naked, striped caterpillars of this insect. These hordes of larvæ usually travel in one direction, passing from one field to another, destroying crops as they go. They have a habit, also, of climbing the stalks of such grasses as timothy and the small grains and cutting off the stems just below the head.

The army worm seems to be an indigenous North American insect, but has become widely distributed in foreign countries, and is now practically cosmopolitan. It, however, is not known to be especially injurious outside of the United States, and as an injurious farm pest its damage is practically confined to the region east of the Rocky Mountains, including Texas, and north of the tier of Gulf States.

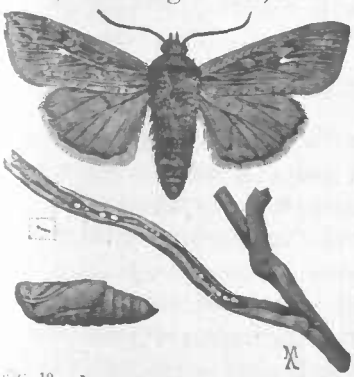

FIG. 19.—*Leucania unipuncta*, moth above, pupa below, and eggs in natural position in a grass leaf, all natural size (from Comstock).

Description.—The adult insect is a pale or yellowish brown moth, with a white spot on the center of each fore-wing. Its minute white eggs are usually laid in numbers from two to three to twenty in strings beneath the sheaths of grass stems, a strong effort evidently being made by the female moth to conceal her litter. They are occasionally deposited also in other situations or beneath the leaf sheaths or loose bark of other plants.

The eggs hatch in from eight to ten days, and the young caterpillars feed for a time in the fold of the leaf, but grow rapidly and soon consume entire leaves.

[1] This general account of the insect is condensed from Circular 4, second series, Division of Entomology, prepared by Dr. Howard.

The larvæ.—Under ordinary circumstances the larvæ feed mainly at night, or in damp, cloudy weather, remaining hidden during bright days, resembling in this habit the closely allied cutworms. They reach full growth in three or four weeks, attaining a length of 1¼ inch, burrow into the ground, and transform into brown chrysalides. In this condition they remain in the summer an average of two weeks before yielding the perfect moths.

Number of generations.—Several generations are produced each season; two or three in the Northern States and four or five or perhaps six in the Southern States.

The army worm, as a rule, passes the winter in the half-grown larval condition, occasionally in the South hibernating as a moth, and perhaps rarely in the egg stage.

This insect is present in grass land probably every year in greater or less numbers, but on account of the habit of concealment of the larva it is very rarely noted. It attracts attention and becomes a matter of grave concern only when, as a result of a series of favorable years or exceptionally favorable local conditions, it suddenly develops in enormous numbers and is forced by scarcity of food and hunger to migrate in swarms from its breeding grounds, and travels and feeds both during the day and night.

The over-wintered larvæ appearing suddenly in spring may occasionally attract notice, but as a rule the notable and destructive swarms are the progeny of the first, second, or third summer broods. In general, it may be said that these worms are more apt to make an injurious appearance in a rainy spring or early summer following a season of comparative drought. This was well illustrated in the case of the outbreaks of 1888, and especially 1894.

PREVENTIVES AND REMEDIES.

As already noted, the fact that the army worm occurs at very irregular intervals—usually widely separated, and as a rule without warning—renders it impracticable to get farmers to undertake preventive measures. In general, however, it is true that clean cultivation and the adoption of a regular system of rotation of crops in which grass lands are alternated every few years with cultivated fields will keep this insect in check and probably prevent an unusual multiplication of it. Bearing in mind also the fact that it breeds normally in rank grass and over-winters in such situations, it is of importance to burn over such tracts early every winter, which will kill many of the larvæ and leave the others to be destroyed by exposure. If these measures be practiced the army worm will probably never be able to get a migratory start, or, in fact, become abundant enough to necessitate migration.

Spraying.—The discovery of this insect is commonly made only when the advancing armies of worms have already entered valuable fields of wheat or other grain, and in case of fields so invaded nothing of a really practical nature can be done to prevent loss. Such fields may be sprinkled, by means of broadcast sprayers, with an arsenical solution, or rolled with a heavy roller when the ground is level, or pastured by a flock of sheep, which will destroy many of the worms by trampling. The arsenical application, however, will probably not save the crop, because the worms will eat enough of the crop to destroy it before they are themselves killed, and the other measures are not applicable in many cases. The main effort under such conditions should be directed toward preventing the larvæ from reaching other fields.

Distribution of poison across their line of march.—One of the best remedies available in this latter direction is the old-time one of plowing a furrow with its perpendicular side toward the field to be protected and the subsequent dragging of a log through the furrow to keep the earth friable and kill the worms which have accumulated in the ditch; another is to poison heavily with Paris green or London purple in solution a strip of pasture or field crop in advance of the traveling army of worms. In the same line is the distribution of quantities of a bran, arsenic, and sulphur sugar mixture across their line of march. The general destruction of the worms themselves by direct applications is hardly practicable, and as a rule they can be safely left to the action of their natural parasites, which at this season are apt to be very much in evidence.

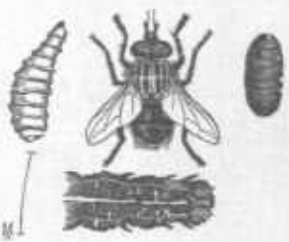

FIG. 20.—The red-tailed tachina fly, with its larva at left and its puparium at right; below is the forepart of the body of an army worm with tachina eggs attached, somewhat enlarged (from Comstock).

Natural enemies.—In the case, perhaps, of no other insect of equal economic importance is the action of natural enemies more effective than with the army worm, and this is especially true when its migratory instinct drives it forth from its normal protection and concealment from its natural enemies in some tuft of rank-growing grass. These enemies are species of parasitic tachina flies, rather larger than the house fly, which deposit eggs all over the bodies of the larvæ. From these eggs maggots hatch and penetrate the larvæ, feeding on its internal organs and eventually destroying it. One of these species, known as the red-tailed tachina fly (fig. 20), named after its host, *Nemorœa leucaniæ*, may often be seen in hundreds buzzing about a field infested with the army worm, and sometimes as many as fifty of its eggs are attached to a single caterpillar. So efficient is this fly, as a rule, that on occasions of unusual increase of the army worm practically every

worm is parasitized, and the insect is so reduced in numbers that it does not again become abundant for a number of years, in some instances not reappearing for twelve or fourteen years. The action of this parasitic fly is assisted by various predaceous beetles, which prey upon the larvæ.

THE GRASS WORM, OR FALL ARMY WORM.

(*Laphygma frugiperda* S. & A.)

This species (fig. 21) resembles the last closely in habit, but is more distinctively southern in its range, occurring from New York and Illinois southward throughout the Southern States. The fall brood of larvæ is the one which is usually troublesome, hence its name of fall army worm. It is chiefly destructive to grasses, but occasionally raids wheat fields and destroys the young winter wheat. The half-grown larvæ in such instances suddenly appear in or migrate into the wheat fields from neighboring grass lands, and feed on the wheat voraciously from the end of September until they reach full growth, some time about the 1st of October. They then enter the ground and winter in the chrysalis stage, the adults appearing in May. Like the true army worm, there are several summer broods, and in general habits and characteristics the two species are closely similar. Both the moth and the larva are extremely variable as regards colors. The moth is bluish-gray in color, with dusky wing markings, being more mottled than the army-worm moth. The larva is very dark brown in color in fall, giving the effect of an almost black insect. It is marked with a broad buff band along the sides and a narrow yellow line on the back. The under surface is greenish, more or less mottled with yellow.

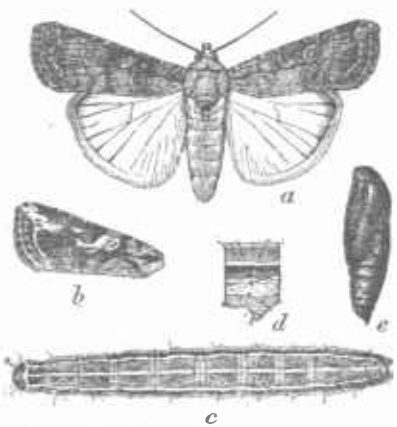

FIG. 21.—Fall army worm (*Laphygma frugiperda*): *a*, moth, plain gray form; *b*, forewing of Prodenia like form; *c*, larva extended; *d*, abdominal segment of larva, lateral view; *e*, pupa, lateral view—*d*, twice natural size; others enlarged one-fourth (from Chittenden).

REMEDIES AND PRECAUTIONS.

The remedies and precautions suggested in the case of the army worm apply equally to this species, which is also probably kept in check normally by similar, and often by the same, parasitic enemies.

THE WHEAT SAWFLIES.

There are quite a number of sawfly larvæ which are occasionally found in wheat fields. Most of these have very little economic importance

and are only chance migrants to wheat from various wild grasses on which they normally feed. When seen, however, by the farmer they often arouse fears and are charged with damage with which, very likely, they have nothing to do.

The adult insects are four-winged flies, belonging to the order Hymenoptera, which includes the bees and wasps. They are termed sawflies in description of the sawlike ovipositor of the female insect with which she makes incisions in the tissues of plants for the insertion of her eggs. The larvæ of the species working on wheat either bore the stems or feed externally on the leaves. The stem borers are the more distinctively wheat pests and are capable of doing much more damage.

STEM-BORING SAWFLIES.

Two species may be especially noted as being of possible importance in this country: First, the so-called European corn fly (*Cephus pygmæus*) (fig. 22) and a native species (*Cephus occidentalis*) which occurs in California and works in a similar manner in the stem of a hollow grass, probably a species of Elymus.

The imported species, which is here better known as the European wheat sawfly, was first identified as occurring in this country about 1887 in New York[1] and shortly afterwards in Canada, and was carefully studied by Professor Comstock at Cornell University. Up to the present time in this country it has never occasioned much loss. In Europe it is a well-known pest and, especially in France, is much feared.

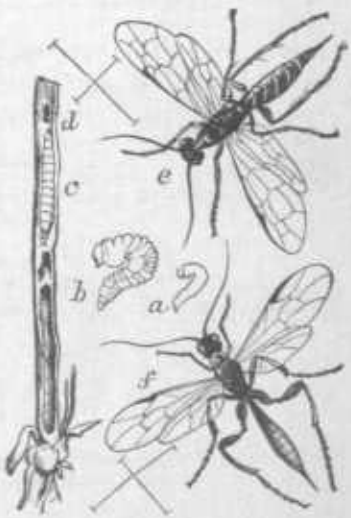

FIG. 22.—European wheat sawfly (*Cephus pygmæus*): *a*, larva; *b*, same enlarged; *c*, same in wheat stalk; *d*, frass; *e*, adult female; *f*, its European parasite (*Pachyneurus calcitrator*)—sizes indicated by hair lines (reengraved from Insect Life).

How they pass the winter.—The adult flies appear in April and deposit eggs in the stems of the young wheat. The larvæ bore through the joints and work up and down the full length of the stem. When full grown they attain a length of half an inch and are milky white in color. With approaching harvest they pass down to the bottom of the stem and cut the straw circularly on the inside, nearly severing it. Beneath this cut they form a little cocoon just at the base of the stem, within which they pass the winter in the larval stage, transforming to pupæ and emerging as adult insects in the following summer. The object of the cut made just above their cocoon is to cause the straw to break and allow the perfect insect to more readily escape

[1] The species was first collected in this country by Mr. F. H. Chittenden, at Ithaca, N. Y., about 1881 or 1882 (Ins. Life, Vol. IV, p. 344).

from the stem, and the damage done by this insect is chiefly in the falling or lodging of the grain which often results from the weakening of the straw at the point indicated. Otherwise very little harm results, and the heads of attacked wheat are, as a rule, well filled.

Breeds in wheat.—This insect breeds in wheat in preference to other small grains. In fact, it is doubtful whether it often successfully develops in other grains than wheat and rye, although the females will oviposit in oats and even in the stems of grasses.

WESTERN WHEAT SAWFLY.

(*Cephus occidentalis* Marlatt.)

This insect (fig. 23) is in habit exactly similar to the European wheat sawfly, and the adult insect closely resembles the European species. Its economic importance arises from the fact that it may at any time be expected to abandon its native food plants in favor of the small grains,

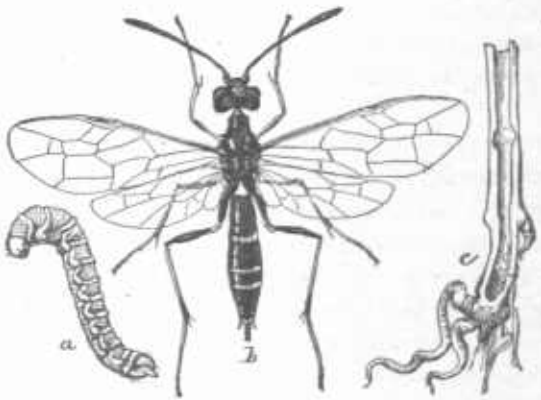

FIG. 23.—Western wheat sawfly (*Cephus occidentalis*): *a*, larva; *b*, female sawfly; *c*, grass stem showing work—*c*, enlarged; *a*, *b*, more enlarged (author's illustration).

in which it can undoubtedly successfully develop. Such changes in the food habits of our native insects are being constantly witnessed, as is illustrated by several of the species already discussed and the leaf-feeding wheat sawflies, which normally affect wild grasses.

LEAF-FEEDING SAWFLIES.

As already indicated, several native American sawflies occasionally attack growing wheat. These are all species which normally feed on wild grasses. The larvæ of some half dozen species of the genus Dolerus have been found on wheat. The adult insects of all of these are similar, and the species *Dolerus arvensis* Say (fig. 24) may be taken as a characteristic representative of them. It is a blue-black fly, somewhat larger than the house fly, very sluggish in habit and ordinarily found in swampy places on grass in early spring. The larvæ of these

insects attain a length of nearly an inch, are usually dull or dirty whitish in color, with the head marked with brown. Some of them are also marked with brown stripes or spots along the side of the body. They occur, as a rule, singly and are rarely in sufficient numbers to be of any economic importance.

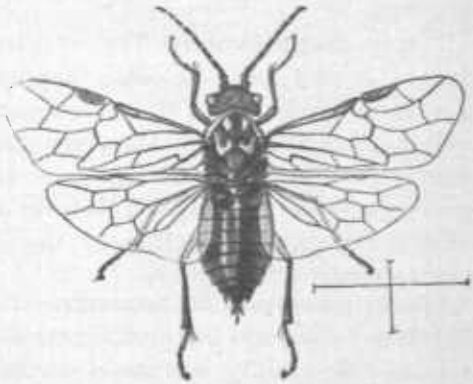

FIG. 24.—Leaf-feeding sawfly (*Dolerus arvensis*): female—enlarged (author's illustration).

GRASS SAWFLY (*Pachynematus extensicornis* Nort.).

A more important species is the insect bearing the scientific name of *Pachynematus extensicornis* Nort. (fig. 25), a grass sawfly about the size of a common house fly, which occurs throughout the Northern States east of the Rocky Mountains. The eggs of this insect are inserted in rows along the edge of the blades of wheat, or more commonly in grasses, and the larvæ hatching from these feed on the leaves

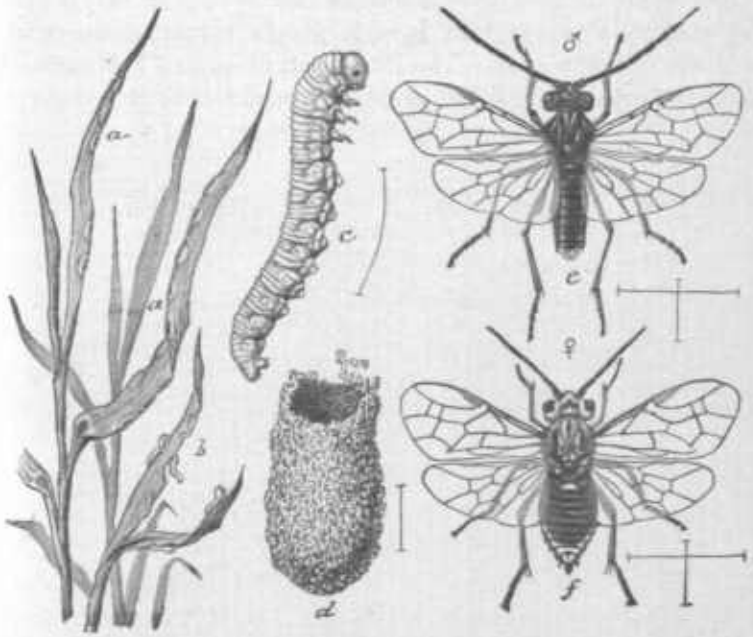

FIG. 25.—Grass sawfly (*Pachynematus extensicornis*): *a*, eggs in wheat blades; *b*, young larvæ; *c*, full-grown larva; *d*, cocoon from which adult has issued; *e*, male; *f*, female—*a* and *b* natural size; *c-f*, enlarged (author's illustration).

more or less gregariously while young. As they become full grown they separate and become practically solitary feeders, as in the case of the larvæ of Dolerus. They may be distinguished from the latter,

however, by being uniformly yellowish green in color, with the head similarly colored, with the exception of the two minute brown eye-spots, and by the possession of seven instead of eight pairs of abdominal feet.

Damage inconsiderable.—This species, also, can scarcely be considered as having great economic importance. So far as they work on the leaves of the wheat their damage is inconsiderable, but occasionally they are attracted by the green portion of the stem just below the head, especially as the wheat ripens, and sever the stalk at this point, causing considerable loss. This form of damage is more characteristic of the Dolerus species than of the species last described, which is more strictly a leaf feeder.

Special precautions not necessary.—The fact that damage from both the stem-boring and leaf-feeding sawflies has never been very considerable in this country has made it unnecessary to adopt any special precaution with regard to them. Where land is deeply plowed and replanted in the fall both the stem borers and the leaf feeders will be buried too deeply to escape. The only danger, therefore, comes from land that is left in stubble over winter or long enough for the adult insects to emerge in spring. Should any of these insects ever assume any especial importance, they doubtless can be kept in easy control by seeing that all wheat-stubble land is deeply turned under with the plow in the fall or winter. The likelihood of serious infestation from neighboring grass lands is not great, although not to be ignored.

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